

Seismological evidence for a transition from "hydrous" oceanic crust to typical oceanic crust in the Lau back-arc basin

ARAI, Ryuta^{1*} ; DUNN, Robert¹

¹University of Hawaii

The Lau back-arc basin, associated with subduction of the Pacific plate beneath the Indo-Australian plate at the Tonga Trench, provides a superb study area to understand the interaction between plate subduction and back-arc spreading: Subducting oceanic lithosphere induces mantle corner flow within the mantle wedge above the subducting plate and releases a large amount of water and other elements into this wedge, producing heterogeneous chemical compositions and fluid gradients beneath the back-arc basin. While petrological studies suggest that the heterogeneity in the mantle source composition, mainly caused by slab-derived fluids, plays an important role for melt supply to the back-arc ridges, variations in thickness and internal structure of crust formed along back-arc ridges are poorly documented. On the basis of seismic tomography analyses, we present a structural model of crust formed along the Eastern Lau Spreading Center within the Lau back-arc basin as evidence for a transition from a "hydrous" type of oceanic crust to a more typical oceanic crust. The seismic data indicate that as the back-arc spreading center moved away from the active arc, the crust thinned from 8-9 km to ~7 km, the lower crust changed from high P wave velocity values (7.2-7.4 km/s) to typical values for oceanic crust (7.0-7.2 km/s), and the upper-crustal volcanic layer changed from a thick low-velocity layer to a thinner layer with more typical wave speeds. The seismic results, in combination with other geophysical and geochemical data, suggest that crustal formation along the ELSC is strongly controlled by the influence of slab water: When a spreading center is near the active arc, water from the downgoing slab is entrained in the melting zone beneath the back-arc ridges where it enhances melting. Thereafter, the water enhances crustal differentiation within sub-ridge magma chambers. This creates an anomalous "hydrous" form of oceanic crust with a thick felsic volcanic layer and a mafic/ultramafic lower crust - features that are not typically observed in crust formed at mid-ocean ridges. The Lau basin has a zoned structure with an abrupt transition from this type of oceanic crust to more typical oceanic crust, which resulted from a rapid change in the influence of slab water as the ridge moved away from the arc. The unique geodynamic setting of the Lau basin, such as proximity of the back-arc ridges to the volcanic arc (<100 km), the relatively low subduction angle of the slab (~45 degrees), and the fast subduction rate at the Tonga trench (>20 cm/yr), probably operate to effectively deliver slab-derived water far beyond the volcanic arc to the back-arc ridges and produce this "hydrous" oceanic crust in the back-arc basin. The abundance and high rate of production of the "hydrous" crust suggests that such crust may make up a significant proportion of the arc-like crust that forms continents.

Keywords: Back-arc basin, Crustal differentiation, Oceanic crust, Slab water, Seismic tomography, Eastern Lau Spreading Center